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Submitted to the journal

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Journal	OnLine Journal of Biological Sciences
Manuscript Title	The Utilization of Red Cabbage Extract ( <i>Brassica oleracea</i> ) in the Production of Avocado ( <i>Persea americana</i> Mill) Freshness Indicator as Smart Packaging Element
Abstract	<p>This research aimed to study and produce smart packaging indicator by utilizing red cabbage extract which could be applied to avocados. The research was conducted in a laboratory with the following stages; making red cabbage extract, preparing color indicator and applying to smart packaging. The results showed that the soaking time and pH of the red cabbage extract solution as an indicator solution which was suitable for making freshness indicator of avocado were 15 hours with the temperature of <math>28 \pm 2^{\circ}\text{C}</math> and pH 7. The color indicator that had been applied to the packaging had a color change from light purple to red that visible with the naked eye. The color change of the indicator reflected the freshness level of packaged avocado, in which the purple color showed mature, yellowish blue showed the optimal ripe fruit while the red color indicated the fruit rotten during storage. Changes in indicator also had a similar tendency towards changes in several parameters such as increasing pH, total acid, vitamin C, hardness and total dissolved solids which are usually used to characterize the freshness of avocados. Organoleptic tests namely color, aroma, texture and taste showed that the panelists preferred the avocado on day 4. In general, this indicator could be used as smart packaging</p>
Key Words	Avocado, Red Cabbage Extract, Indicator, Smart Packaging

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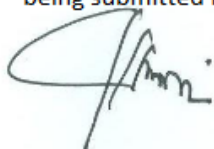
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Original Research Paper

# The Utilization of Red Cabbage Extract (*Brassica oleracea*) in the Production of Avocado (*Persea americana* Mill) Freshness Indicator as Smart Packaging Element

Andi Dirpan<sup>1</sup>, Muspirah Djalal<sup>2</sup>, Riskawanti Rahman<sup>3</sup>, Jalil Genisa<sup>4</sup><sup>1,2,3,4</sup>Department of Agriculture Technology, Hasanuddin University, Makassar, Indonesia**Article history**

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**Abstract:** This research aimed to study and produce smart packaging indicator by utilizing red cabbage extract which could be applied to avocados. The research was conducted in a laboratory with the following stages; making red cabbage extract, preparing color indicator and applying to smart packaging. The results showed that the soaking time and pH of the red cabbage extract solution as an indicator solution which was suitable for making freshness indicator of avocado were 15 hours with the temperature of  $28 \pm 2^\circ\text{C}$  and pH 7. The color indicator that had been applied to the packaging had a color change from light purple to red that visible with the naked eye. The color change of the indicator reflected the freshness level of packaged avocado, in which the purple color showed mature, yellowish blue showed the optimal ripe fruit while the red color indicated the fruit rotten during storage. Changes in indicator also had a similar tendency towards changes in several parameters such as increasing pH, total acid, vitamin C, hardness and total dissolved solids which are usually used to characterize the freshness of avocados. Organoleptic tests namely color, aroma, texture and taste showed that the panelists preferred the avocado on day 4. In general, this indicator could be used as smart packaging

**Keywords:** Avocado, Red Cabbage Extract, Indicator, Smart Packaging

## Introduction

Avocado is a type of climacteric fruit. Climacteric fruit is a fruit that has increased respiration and ethylene during the fruit ripening (Cherian, Figueroa, and Nair 2014). Based on the data of the Directorate General of Indonesia Horticulture in 2015, avocado is classified as one of the fresh fruit commodities with a high level of production targets. The target of avocado production in 2015-2019 is around 300,780 - 325,561 tons. However, avocados are very susceptible to damage either due to the microbiological disturbances, environmental temperature or mechanical damage. Mechanical damage is caused by transportation with a very long distance. This is due to the tendency of the fruit that does not have a uniform shape and size causes susceptibility to experience friction. Consequently, avocados have a relatively short shelf life.

One way to minimize damage to avocados is by using smart packaging (S.-I. Hong and Park 1999;

Yam, Takhistov, and Miltz 2005; B Kuswandi, Wicaksono, and Abdullah 2011; Andi Dirpan et al. 2018). Smart packaging is a package equipped with indicators to monitor the quality and safety of food products during storage, transportation, and marketing (Bambang Kuswandi et al. 2012; Siracusa et al. 2008; Hidayat et al. 2019; A Dirpan et al. 2019; Julyaningsih, Latief, and Dirpan 2020; Yolanda et al. 2020). Several studies about smart packaging in the form of indicator labels have been carried out. Dirpan et al. (2018) has been researching smart packaging color indicator to detect the quality of mango (Andi Dirpan et al. 2018). Besides that, previous studies have implemented smart packaging in beef (Bambang Kuswandi and Nurfawaidi 2017), milk (Cavallo, Strumia, and Gomez 2014), shrimp (Bambang Kuswandi et al. 2012), kimchi (fermented vegetable product) (S. I. Hong and Park 2000; S.-I. Hong and Park 1999) and guava (Bambang Kuswandi and Maryska 2013).

One source of natural dyes can be obtained from the

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commodity of red cabbage. Red cabbage is a plant that contains a lot of anthocyanins. Anthocyanin is a pigment that can dissolve in water. Chemically anthocyanins can be grouped into flavonoids and phenolics. These substances play a role in the coloration of red cabbage (Harborne et al. 2006). So that in this research red cabbage will be utilized as a natural indicator that will be immobilized into paper Whatman no. 1.

The application of smart packaging with the use of red cabbage extract as an indicator of avocados freshness has not been applied. Therefore, this study aimed to understand: how to make smart packaging element as an indicator of fruit freshness in avocado (*Persea Americana Mill*) with the utilization of red cabbage extract (*Brassica oleracea*)? how to apply smart packaging to avocados?, and What is the color change profile on the freshness indicator of the avocado (*Persea Americana Mill*)?.

## Research Method

### *Time and Place*

This research was conducted on April-June 2018 in the Laboratory of Food Microbiology and Biotechnology, Laboratory of Chemistry Analysis and Food Quality Control, and Laboratory of Food Processing, Program Study Food Science and Technology, Departement of Agricultural Technology, Hasanuddin University, Makassar.

### *Equipment and Materials*

Equipment used in this experiment were hair dryer (Philips), Erlenmeyer 300 ml, drop pipette, hot plate, penetrometer, pH meter, knife, basin, mortar and pestle, stirrer, analytical balance, funnel, blender, centrifuge, volumetric flask, bulb, volume pipette, hand refractometer, beaker glass, digital microscope (model: digital microscope 5-500 x) and titration set manual.

Materials used in this experiment were: avocados, red cabbage, NaOH solution, HCl solution, styrofoam, Whatman paper No. 1, ethanol, aquadest, amyllum solution, phenolphthalein solution, iodine solution, polyethylene plastic, aluminum foil, tissue, and label.

## Research Procedure

The research conducted consisted of two stages, namely, preliminary and main research.

### *Preliminary Research*

### *Red Cabbage Extract Making*

We cut red cabbage into small pieces and then weighed an amount of 600 grams. After that, the cabbage was mashed with a blender and macerated with 160 mL ethanol-distilled water (ratio 7:3). We adjusted the pH of the sample to 2.0 with HCl (1 mol/L). Then, the material was stored at 10°C in the refrigerator for 24 hours. We then centrifuged the cabbage solution at 5000 rpm for 20 minutes. The centrifugation resulted cabbage extract. Cabbage extract was then filtered using Whatman paper No. 1 to obtain clear cabbage extract. Clear cabbage extract was then adjusted to alkaline condition (pH 7, 9 and 11). Modified from (Silva-Pereira et al. 2015).

### *Preparation of the Color Indicator Label*

We cut the Whatman no 1 paper sheets in size 2×4 cm then we soaked it in 10 mL of red cabbage indicator solution at room temperature (28±2°C) for 5, 15 and 30 hours. The treatment was carried out to obtain the best treatment in producing color changes. If the indicator solution succeeded in reacting with Whatman paper, it would give light purple on Whatman No. 1 which was white. Next, Whatman No. 1 dried with an electric dryer.

### *Main Research*

#### *Smart Packaging Application on Avocado Fruit*

We weighed around 500 grams of Avocado by two pieces (each packaging container), then placed it on a styrofoam tray. Then the indicator paper was affixed to the packaging label and placed in the packaging, by attaching the packaging indicator label to the polyethylene plastic as a styrofoam cover. Samples were stored in room conditions (28 ± 2°C) with normal light exposure. Triple packages of avocado products taken at the right time interval (every 1 day for 7 days) for analysis of pH, total vitamin C, total dissolved solids (TDS), total acid, fruit hardness and color index on packaging indicator paper of avocado.

### *Research Design*

The research design that was carried out for preliminary research was the determination of the pH of the indicator solution and the determining of the best soaking time. The type of pH of the indicator solution and soaking time were:

- A1: Red cabbage extract solution pH 7
- A2: Red cabbage extract solution pH 9
- A3: Red cabbage extract solution pH 11
- B1: Soaking for 5 hours
- B2: Soaking for 15 hours
- B3: Soaking for 30 hours

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The best treatment from each of the mentioned steps was then used in the primary research for making smart packaging indicators for avocados. Then, the indicator label was applied to the packaging of avocados with a storage time of 7 days in a room temperature ( $28 \pm 2^\circ\text{C}$ ).

### Observation Parameters

The observation parameters were carried out by several tests, namely pH measurement Method (AOAC 1995), total acid titration method (Retnowati and Kusnadi 2014), total dissolved solids (hand refractometer) (Hurriyah, Kuswandi, and Pratoko 2017), Vitamin C (Helmiyesi, Hastuti, and Prihastanti 2008), organoleptic in the form of texture, taste, color and aroma method by (Setyaningsih, Ariyantono, and Sari 2010) and quantification of indicator color measurement (F.J. Francis 1994; Gunasekaran 1996; K.L. Yam, S.E. Papadakis 2004).

## Result and Discussion

Based on the results of preliminary research conducted, it was known that the soaking time and pH of the red cabbage extract solution as an indicator solution suitable for making indicators of avocado freshness were 15 hours with the temperature of  $28 \pm 2^\circ\text{C}$  and pH 7. It can be seen through the significant color change of the indicator label that was applied to the avocado. The use of red cabbage extract as a natural solution immobilized to Whatman paper number 1 which produced an indicator label that was applied to avocados could change in color due to the release of volatile acids such as acetic acid in avocados during storage which is directly bound to the indicator. The color purple indicated that the fruit is highly fresh, then experiencing a change in color to yellowish blue showed fresh fruit and turning to red indicated that the fruit is experiencing the beginning of decay.

### pH

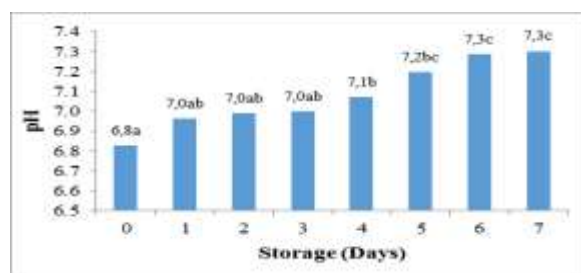


Fig 1. The results of pH measurement on avocados during storage.

Based on the pH measurement of packaged avocados using pH meters results, it showed that there was an increase in pH every day during storage. The

results of the analysis of variance showed that the pH value on day 0 was significantly different from day 4,

5, 6, and day 7 and not significantly different from day 1, 2, and day 3. The measurement results of the pH value of avocados on day 0 was around 6.8 while the day 7 showed a pH value of 7.3. The increase in pH is due to the avocado being a climacteric fruit in which when storing the ripening process is still undergoing. During the ripening process, the fruit acidity decreases and results increase in pH. This is in accordance with (Muchtadi 2010) which state that young fruit contains a lot of organic acids that will decrease during the fruit ripening process and is supported by a statement (Bambang Kuswandi et al. 2012) that pH changes can significantly be known because of the formation of acetic acid during the ripening process.

### Total Acid

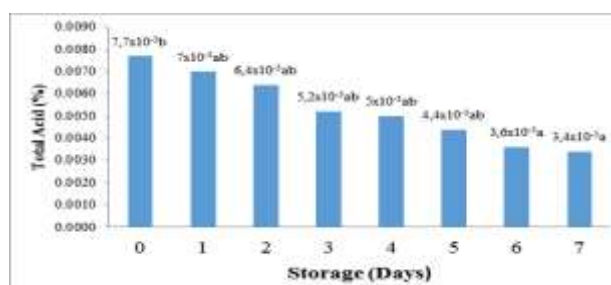


Fig 2. Total Acid Measurement Results on Avocado Fruit during Storage.

The results of variance analysis showed that total acid on day 0 was significantly different from total acid on day 6 and 7 and was not significantly different from day 1, 2, 3, 4 and 5. The total acid value on day 0 is around  $7.7 \times 10^{-3}\%$  and has decreased to  $3.4 \times 10^{-3}\%$  on day 7. The reduction in the total acidity of avocado packaged during storage is caused by the use of organic acids in avocados during the respiration process which requires energy during storage, the energy needed is obtained by overhauling nutrients contained in food. Also supported by (Tranggono and Sutardi 1989) stated that the total content of acid would decrease during the maturation period and together with the decrease in total acid, a reduction in starch content occurs.

### Total Dissolved Solids (TDS)

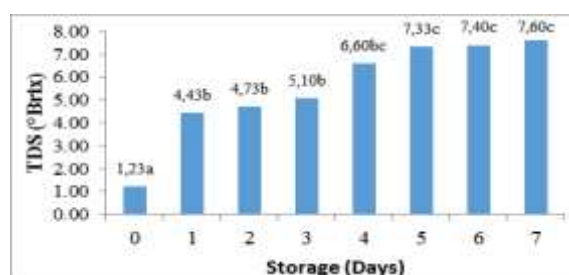


Fig 3. Total Dissolved Solids of Avocado Fruit during Storage.

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Based on analysis of variance, avocados stored for seven days showed that the TDS on day 0 was significantly different from the TDS on other days from day 1 to day 7. While the TDS on the first day was significantly different from day 0, 5, 6 and 7 and not significantly different from day 2, 3 and 4. The test results for total dissolved solids on day 0 showed a value that was equal to 1.23°Brix and experienced an increase on day 7 which was 7.60 °Brix. Based on these results it was known that during the storage, total dissolved solids on avocados increased. The step up in total dissolved solids is caused by the breakdown of carbohydrate polymers, especially starch in avocados, into sugar resulted in an increase in sugar content in general. This result is consistent with (Buckle and Edward 2013) statement that the higher the concentration of sucrose contained in a ripe fruit will produce a high total dissolved solid.

### Vitamin C

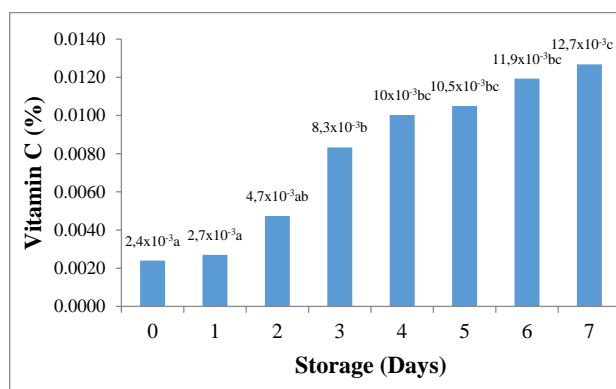


Fig 4. Vitamin C Measurement Results of on Avocado Fruit During Storage.

The results of variance analysis showed that the vitamin C content on day 0 was significantly different from the day 3, 4, 5, 6 and 7 and was not significantly different from the day 1 and 2. The results of vitamin C measurement on the day 0 showed a value that was equal to 2.4x10<sup>-3</sup>% and continuously increased until day 7 which reached 12.7x10<sup>-3</sup>%. The increase of vitamin C content is because generally in fruits contain vitamin C, the vitamin C increase is in accordance with the development of fruit. When the fruit is still in a young state the content of vitamin C is very low while when the size of fruit reaches the maximum level, same goes to the vitamin C. This is in accordance with (Pantastico 1975) which state that the content of vitamin C in fruit is usually in accordance with the development of fruit. Young fruit contain low level of vitamin C while when the fruit size reaches the maximum level, the vitamin C is also maximum.

### Hardness

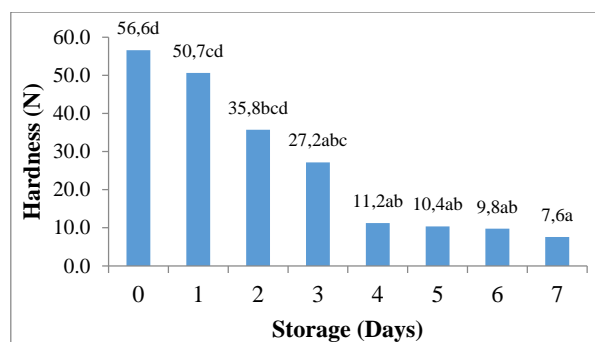


Fig 5. Measurement Results of Hardness Level on Avocado Fruit during Storage.

The results of analysis of variance showed that the hardness level of avocados on day 0 was significantly different from day 3, 4, 5, 6 and day 7 and not significantly different from the day 1 and 2. The value of the hardness level of avocados showed that on the first day was 56.6 N and decreased gradually up to 7.6 N on day 7. Decrease in the hardness of avocados during storage due to the hydrolysis of cell wall composition during the ripening process. This result was supported by (Nelson, Ploetz, and Kepler 2006) that during the ripening process of fruit, the hydrolysis of pectin and hemicellulose which is a component that forms cell walls occurs and causes fruit softening

### Color Change Index

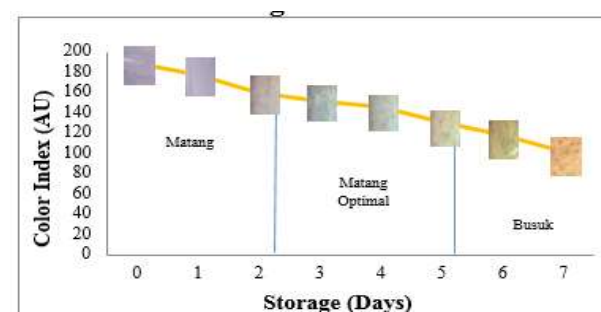


Fig 6. Color Change Profile on the Indicator of Avocado Freshness.

The results of these observations indicated that there was a color level change of the indicator (the intensity of purple that changes) to various levels of freshness during storage. In Fig 6, the color change response decreased continuously (the change became red), in which on day 0, the intensity of the light purple color is 189 AU. While on

DOI:

day 7, it decreased to 121 AU. Color changes that occur are due to the release of volatile acids such as acetic acid in avocados during storage which is directly bound to the indicator. The purple color indicated mature fruit (in this condition the fruit has physical characteristics if observed in a visual way, in which the surface of the fruit skin looked like there is a layer of wax, fresh dark green, had a solid and filled shape, had a hard texture and a bit bitter taste). Indicator color changes to yellowish blue indicated that the fruit ripens optimally (this condition the fruit experiences a decrease in hardness or softening fruit, green fruit flesh color, green fruit skin color is less fresh, and sweet taste). Changing the color of the indicator from yellowish blue to red indicates that the packaged fruit has been decayed (in this condition the texture of the fruit is getting softer, the taste of the fruit is sweet and somewhat bitter, the skin color of the fruit is not fresh and runny). The result obtained was inconsistent with (Bambang Kuswandi et al. 2012) that all color indicators placed in the packaging are used to detect changes in pH as a result of the biosynthesis of volatile acids which come out gradually in the packaging during the ripening process

### Organoleptic

#### Color

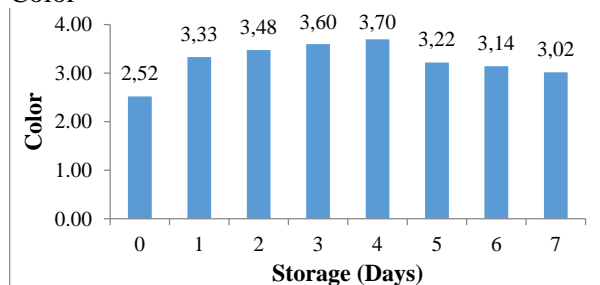


Fig 7. Organoleptic Test for Color in Avocado Fruit during Storage

The panelists' assessment of the color of avocados showed that the color of the fruit preferred by the panelists was fruit at the day 4 of storage with an average value of 3.70. The color Avocado had on day 4 were green color and flesh with yellowish green color. This change is due to the drastic degradation of the chlorophyll pigment during the cooking stage which coincides with the rate of reduction of reducing sugars. The result was in accordance with (Winarno 2008), who stated that color changing in food can be caused by several sources and one of the most important sources is pigments contained in vegetable and animal ingredients.

#### Aroma

The panelists' assessment of the aroma of avocados showed that the fruit aroma preferred by panelists was on day 4 of storage with an average value of 3.74. The aroma produced on day 4 is a distinctive aroma of avocado. This aroma occurred because the fruit has undergone optimal maturation and the release of ethylene or esters during

ripening takes place. This result was supported by the opinion of (Pantastico 1975), who states that a typical odor arises around a ripe fruit which is usually produced when entering the climatic form of aliphatic alcohol esters and short chain fatty acids.

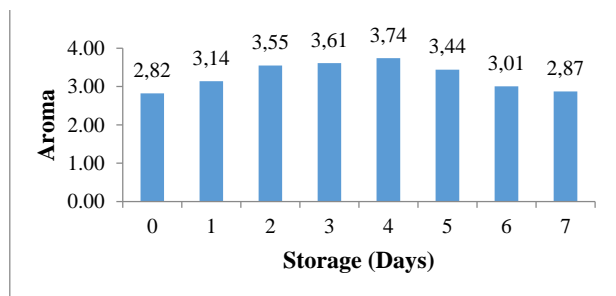


Fig 8. Organoleptic Test of Aroma on Avocado Fruit during Storage

#### Texture

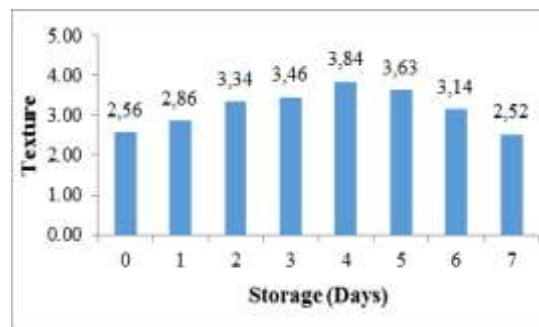


Fig 10. Organoleptic Texture Test on Avocado Fruit during Storage

The panelists' assessment of the texture of avocados showed that the fruit texture preferred by panelists was at day 4 of storage with an average value of 3.84. The texture avocado had on day 4 was the overall texture of the base of the fruit which was still rather hard, but the flesh of the fruit has a soft and not too hard texture. The texture indicated that on the day 4 of storage, avocado experienced the optimal ripening. The occurrence of softening of avocados during storage is caused by hydrolysis of the fruit cell wall component during the ripening process so that the cell component became soft. Texture softening involved enzymes. The enzyme is an enzyme called polygalacturonase that generally found in avocados. This explanation was supported by (Barbut 2014), stating that the fruit ripening process occurs hydrolysis of the components forming the cell wall which causes the fruit to become soft during the ripening process.

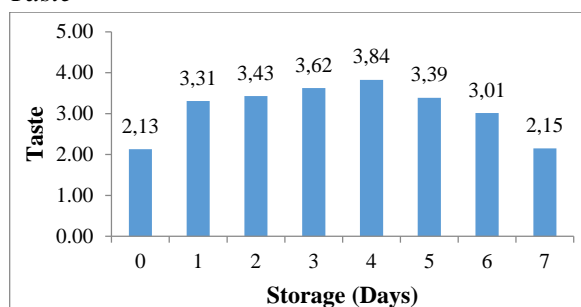
*Taste*

Fig 10. Organoleptic Test on Taste of Avocado Fruit during Storage

The panelists' assessment of avocado flavor showed that the fruit flavor favored by panelists was at day 4 of storage with an average value of 3.84. The taste produced on day 4 is sweet and slightly bitter. This taste indicated that avocados had undergone optimal maturation. This change in taste occurs because of the hydrolysis of starch into simpler sugars, as a result of the breakdown of starch which causes an increase in fruit reducing sugar levels which can cause sweetness and is accompanied by a decrease in levels of organic acids and phenolic substances which is usually related to a sour taste. In addition, the bitter taste was formed from tannins that generally found in avocados. This explanation was in accordance with the statement in accordance with (Winarno 2008) that when the fruit is ripe the sugar flower increases, but the organic acid content decreases as a result the sugar and acid ratio will change so that the fruit tastes better. Also supported by (Tranggono and Sutardi 1989), states that the total acid content will decrease during the ripening period and together with the decrease in total acid, the starch content decreases, while the sugar content as a determinant of fruit sweetness increases.

## Conclusion

The conclusions of this research were:

1. The freshness indicator of avocados can be made by using red cabbage as a natural solution and using Whatman filter paper number 1 as an absorbent material for red cabbage extract with the paper size of  $\pm 2 \times 4$  cm.
2. Application of smart packaging on avocados could be done by placing indicators in the packaging with a

distance of  $\pm 2$  cm from the avocado.

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- Harborne, Alastair R., Peter J. Mumby, Kamila

Revision: minor revision

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Dear Andi Dirpan,

I hope you receive this mail in good health.

We have recently received the evaluation results for your manuscript # 785-OJBS entitled "The Utilization of Red Cabbage Extract (*Brassica oleracea*) in the Production of Avocado (*Persea americana* Mill) Freshness Indicator as Smart Packaging Element" The review decision is as follows:

Minor Revisions: Revise

You are requested to revise your manuscript according to the reviewer guidelines. Please send us your revised manuscript so that we may proceed with the publication process.

Please carefully read the reviewer's comments and respond to each point raised by each reviewer. Your own comments will then be reviewed and compared with the evaluation comments.

Your quick response will be highly appreciated.

Feel free to contact us if you require any further information. I look forward to hearing from you soon.

Regards,

**Zunaira Javed**

*Editorial Office*

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Dear Dr. **Zunaira Javed**

Editor of Journal of OnLine Journal of Biological Sciences

Hope this email finds you well.

First and foremost, I would like to warmly appreciate you, and your specialist reviewers, for your time and consideration on the evaluation of our manuscript.

On behalf of the authors, I believe that our manuscript (manuscript number:) was concisely reviewed by the most knowledgeable and resourceful reviewers of your journal.

For Peer Review

Below, you see all of the comments and responses. Hope these explanations and responses are enough to meet the criteria for eligibility for possible publication.

Sincerely yours.

Dr. Andi Dirpan

Corresponding author

Revised version received

Reviewers' Comments to the Author:

## **Comments Report for Manuscript # 785-OJBS**

### **Final Decision: Minor Revisions**

#### **1st Review:**

Better to review the punctuations and grammer points like The punctuation in the following, . before Modified is not required. Clear cabbage extract was then adjusted to alkaline condition (pH 7, 9 and 11). Modified from (Silva-Pereira et al. 2015).

*Thanks for the comment. We have revised it in page 2 , column 2, paragraf 2*

This sentence is passive therefore it needs some modifications Next, Whatman No. 1 dried with an electric dryer.

*Thanks for the comment. We have revised it in page 2, column 2, paragraf 2*

From where have the avocados been supplied? Their details can be more useful for understanding better the results and concluding the findings.

*Thanks for the comment. We have revised it in page 2 ,column 1, paragraf 5*

If available, some photos of Whatman papers and avocados can be of help for readers to know how the colors were.

*Thanks for the comment. We have added it in page 3 , column 1, paragraf 1*

## 2nd Review:

Review report for the article entitled: The Utilization of Red Cabbage Extract (*Brassica oleracea*) in the Production of Avocado (*Persea americana* Mill) Freshness Indicator as Smart Packaging Element Overall, the manuscript falls within the scope of the OnLine Journal of Biological Sciences. The paper is generally well written and well structured. Also, the subject addressed in this article is worthy of investigation. this original paper investigates for the first time the utilization of red cabbage (*Brassica oleracea* L.) as an indicator of Avocados' (*Persea americana* Mill.) freshness. However, there are some issues detailed below that must be addressed in this manuscript before the paper is accepted for publication. Minor revisions (writing deficiencies) Title: Clear and concise (no comments)

Abstract: P1. Line 4: Consider inserting a comma before 'and'. (...preparing color indicator, and applying ...) P1. Line 5: Add it in the following sentence (...color indicator, and applying 'it' to smart packaging...) P1. Line 13: The sentence 'Changes in indicator also had ...' is too wordy, consider changing it with 'Indicator changes...'

*Thanks for the comment. We have revised it in the abstract*

Keywords: see Suggestions/recommendations below.

*Thanks for the comment. We have revised the key word*

Introduction: P1. Line 10-11: (...due to 'the' microbiological disturbances, ...), remove the article 'the', its use seems incorrect here. P2. Line 15: Change (Avocados) to (Avocados') which is grammatically correct.

*Thanks for the comment. We have revised it in the abstract*

P2. Line 18: Elements and no element. Research Method: Experiment's design and methods are properly outlined, please indicate the origin of each material and its grade (technique or analytical) used (ex: ethanol (Sigma aldrich, Merck ...))

*Thanks for the comment. We have revised it in page 2 ,column 1, paragraf 5*

Results and discussion • The statistical analysis needs more improvement. I invite you to complete the titles of each figure by adding for each letter used the level of significancy.

*Thanks for the comment. We have added in every figure*

As well as adding a whole paragraph entitled 'Statistical analysis' with the following elements: - the test used for the data analysis (One-way ANOVA ?!). – which software(s) used for the analysis and to draw the figures pH (part)

*Thanks for the comment. We have added it in page 3 ,column 3, paragraf 4*

Please rewrite the following paragraph in the sake of clarity 'The increase in pH is due to the avocado being a climacteric fruit in which when storing the ripening process is still undergoing. During the ripening process, the fruit acidity decreases and results increase in pH.'

*Thanks for the comment. We have revised it in page 3 ,column 2, paragraf 3*

Suggestions/recommendations: • I recommend modifying the keywords, eliminate those that are in the title, and replace them by others to promote and give more information about your work.

*Thanks for the comment. We have revised the key word*

Figures are so small and barely readable, please enlarge them. You can also use some software instead as SPSS or GraphPad Prism.

*Thanks for the comment. Definitely, we did our best to make it figure become clear*

Please rephrase this paragraph : 'In addition, the bitter taste was formed from tannins that generally found in avocados. This explanation was in accordance with the statement in accordance with (Winarno 2008) that when the fruit is ripe the sugar flower increases, but the organic acid content decreases as a result the sugar and acid ratio will change so that the fruit tastes better. Also supported by (Tranggono and Sutardi 1989) ...' till the end.

*Thanks for the comment. We have revised it in page 6 ,column 2, paragraf 2*

# Revised File Required for Manuscript # 785-OJBS

External

Inbox



**Zunaira Javed** <support@scipub.org> Tue, Aug 3, 2021, 1:00 PM

to me

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Original Research Paper

## The Utilization of Red Cabbage Extract (*Brassica oleracea*) in the Production of Avocado (*Persea americana Mill*) Freshness Indicator as Smart Packaging Element

Andi Dirpan<sup>1</sup>, Muspilah Djalal<sup>2</sup>, Riskawanti Rahman<sup>3</sup>, Jalil Genisa<sup>4</sup>

<sup>1,2,3,4</sup>Department of Agriculture Technology, Hasanuddin University, Makassar, Indonesia

### Article history

Received: 7 July 2014

Revised: 28 August 2014

Accepted: 2 September 2014

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University, Makassar,  
Indonesia  
Email: dirpan@unhas.ac.id

**Abstract:** This research aimed to study and produce smart packaging indicator by utilizing red cabbage extract which could be applied to avocados. The research was conducted in a laboratory with the following stages; making red cabbage extract, preparing color indicator and applying to smart packaging. The results showed that the soaking time and pH of the red cabbage extract solution as an indicator solution which was suitable for making freshness indicator of avocado were 15 hours with the temperature of  $28 \pm 2^\circ\text{C}$  and pH 7. The color indicator that had been applied to the packaging had a color change from light purple to red that visible with the naked eye. The color change of the indicator reflected the freshness level of packaged avocado, in which the purple color showed mature, yellowish blue showed the optimal ripe fruit while the red color indicated the fruit rotten during storage. Changes in indicator also had a similar tendency towards changes in several parameters such as increasing pH, total acid, vitamin C, hardness and total dissolved solids which are usually used to characterize the freshness of avocados. Organoleptic tests namely color, aroma, texture and taste showed that the panelists preferred the avocado on day 4. In general, this indicator could be used as smart packaging

**Keywords:** [shelf life](#), [fruit](#), [food quality](#)

### Introduction

Avocado is a type of climacteric fruit. Climacteric fruit is a fruit that has increased respiration and ethylene during the fruit ripening (Cherian, Figueroa, and Nair 2014). Based on the data of the Directorate General of Indonesia Horticulture in 2015, avocado is classified as one of the fresh fruit commodities with a high level of production targets. The target of avocado production in 2015-2019 is around 300,780 - 325,561 tons. However, avocados are very susceptible to damage either due to the microbiological disturbances, environmental temperature or mechanical damage. Mechanical damage is caused by transportation with a very long distance. This is due to the tendency of the fruit that does not have a uniform shape and size causes susceptibility to experience friction. Consequently, avocados have a relatively short shelf life.

One way to minimize damage to avocados is by

using smart packaging (S.-I. Hong and Park 1999; Yam, Takhistov, and Miltz 2005; B Kuswandi, Wicaksono, and Abdullah 2011; Andi Dirpan et al. 2018). Smart packaging is a package equipped with indicators to monitor the quality and safety of food products during storage, transportation, and marketing (Bambang Kuswandi et al. 2012; Siracusa et al. 2008; Hidayat et al. 2019; A Dirpan et al. 2019; Julyaningsih, Latief, and Dirpan 2020; Yolanda et al. 2020). Several studies about smart packaging in the form of indicator labels have been carried out. Dirpan et al. (2018) has been researching smart packaging color indicator to detect the quality of mango (Andi Dirpan et al. 2018). Besides that, previous studies have implemented smart packaging in beef (Bambang Kuswandi and Nurfawaidi 2017), milk (Cavallo, Strumia, and Gomez 2014), shrimp (Bambang Kuswandi et al. 2012), kimchi (fermented vegetable product) (S. I. Hong and Park 2000; S.-I. Hong and Park 1999) and guava (Bambang Kuswandi and

**Deleted:** Avocado, Red Cabbage Extract, Indicator, Smart Packaging

Maryska 2013).

One source of natural dyes can be obtained from the commodity of red cabbage. Red cabbage is a plant that contains a lot of anthocyanins. Anthocyanin is a pigment that can dissolve in water. Chemically anthocyanins can be grouped into flavonoids and phenolics. These substances play a role in the coloration of red cabbage (Harborne et al. 2006). So that in this research red cabbage will be utilized as a natural indicator that will be immobilized into paper Whatman no. 1.

The application of smart packaging with the use of red cabbage extract as an indicator of avocados freshness has not been applied. Therefore, this study aimed to understand: how to make smart packaging element as an indicator of fruit freshness in avocado (*Persea Americana Mill*) with the utilization of red cabbage extract (*Brassica oleracea*)? how to apply smart packaging to avocados?, and What is the color change profile on the freshness indicator of the avocado (*Persea Americana Mill*)?.

## Research Method

### Time and Place

This research was conducted on April-June 2018 in the Laboratory of Food Microbiology and Biotechnology, Laboratory of Chemistry Analysis and Food Quality Control, and Laboratory of Food Processing, Program Study Food Science and Technology, Departement of Agricultural Technology, Hasanuddin University, Makassar.

### Equipment and Materials

Equipment used in this experiment were hair dryer (Philips), Erlenmeyer 300 ml, drop pipette, hot plate, penetrometer, pH meter, knife, basin, mortar and pestle, stirrer, analytical balance, funnel, blender, centrifuge, volumetric flask, bulb, volume pipette, hand refractometer, beaker glass, digital microscope (model: digital microscope 5-500 x) and titration set manual.

Materials used in this experiment were: avocados, red cabbage ([purchased in fresh condition from the supermarket](#)), NaOH solution ([Merck](#)), HCl solution, styrofoam, Whatman paper No. 1 ([Whatman](#)), ethanol, aquadest, amylum solution, phenolphthalein solution ([Merck](#)), iodine solution ([Merck](#)), polyethylene plastic, aluminum foil, tissue, and label.

## Research Procedure

The research conducted consisted of two stages, namely, preliminary and main research.

### Preliminary Research

#### Red Cabbage Extract Making

We cut red cabbage into small pieces and then weighed an amount of 600 grams. After that, the cabbage was mashed with a blender and macerated with 160 mL ethanol-distilled water (ratio 7:3). We adjusted the pH of the sample to 2.0 with HCl (1 mol/L). Then, the material was stored at 10°C in the refrigerator for 24 hours. We then centrifuged the cabbage solution at 5000 rpm for 20 minutes. The centrifugation resulted cabbage extract. Cabbage extract was then filtered using Whatman paper No. 1 to obtain clear cabbage extract. [We filtered the cabbage extract using Whatman paper No. 1 to obtain clear cabbage extract. We then adjusted the pH of extract to alkaline condition \(pH 7, 9 and 11\).](#) Modified from [Silva-Pereira et al \(2015\)](#).

#### Preparation of the Color Indicator Label

We cut the Whatman no 1 paper sheets in size 2x4 cm then we soaked it in 10 mL of red cabbage indicator solution at room temperature (28±2°C) for 5, 15 and 30 hours. The treatment was carried out to obtain the best treatment in producing color changes. If the indicator solution succeeded in reacting with Whatman paper, it would give light purple on Whatman No. 1 which was white. Next, Whatman No. 1 dried with an electric dryer.

### Main Research

#### Smart Packaging Application on Avocado Fruit

We weighed around 500 grams of Avocado by two pieces (each packaging container), then placed it on a styrofoam tray. Then the indicator paper was affixed to the packaging label and placed in the packaging, by attaching the packaging indicator label to the polyethylene plastic as a styrofoam cover. Samples were stored in room conditions (28 ± 2°C) with normal light exposure. Triple packages of avocado products taken at the right time interval (every 1 day for 7 days) for analysis of pH, total vitamin C, total dissolved solids (TDS), total acid, fruit hardness and color index on packaging indicator paper of avocado.



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Fig 1. Smart packaging application on Avocado fruit

### Research Design

The research design that was carried out for preliminary research was the determination of the pH of the indicator solution and the determining of the best soaking time. The type of pH of the indicator solution and soaking time were:

- A1: Red cabbage extract solution pH 7
- A2: Red cabbage extract solution pH 9
- A3: Red cabbage extract solution pH 11
- B1: Soaking for 5 hours
- B2: Soaking for 15 hours
- B3: Soaking for 30 hours

The best treatment from each of the mentioned steps was then used in the primary research for making smart packaging indicators for avocados. Then, the indicator label was applied to the packaging of avocados with a storage time of 7 days in a room temperature ( $28 \pm 2^\circ\text{C}$ ).

### Observation Parameters

The observation parameters were carried out by several tests, namely pH measurement Method (AOAC 1995), total acid titration method (Retnowati and Kusnadi 2014), total dissolved solids (hand refractometer) (Hurriyah, Kuswandi, and Pratoko 2017), Vitamin C (Helmiyesi, Hastuti, and Prihastanti 2008), organoleptic in the form of texture, taste, color and aroma method by (Setyaningsih, Ariyantono, and Sari 2010) and quantification of indicator color measurement (F.J. Francis 1994; Gunasekaran 1996; K.L. Yam, S.E. Papadakis 2004).

### Result and Discussion

Based on the results of preliminary research conducted, it was known that the soaking time and pH of the red cabbage extract solution as an indicator solution suitable for making indicators of avocado freshness were 15 hours with the temperature of  $28 \pm 2^\circ\text{C}$  and pH 7. It can be seen through the significant color change of the indicator label that was applied to the avocado. The use of red cabbage extract as a natural solution immobilized to Whatman paper number 1 which produced an indicator label that was applied to avocados could change in color due to the release of volatile acids such as acetic acid in avocados during storage which is

directly bound to the indicator. The color purple indicated that the fruit is highly fresh, then experiencing a change in color to yellowish blue showed fresh fruit and turning to red indicated that the fruit is experiencing the beginning of decay.

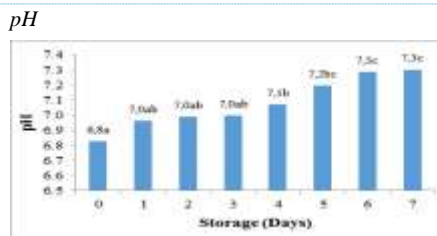


Fig 2. The results of pH measurement on avocados during storage. Mean values (N=3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of pH of avocado fruit during storage

Based on the pH measurement of packaged avocados using pH meters results, it showed that there was an increase in pH every day during storage. The results of the analysis of variance showed that the pH value on day 0 was significantly different from day 4,

5, 6, and day 7 and not significantly different from day 1, 2, and day 3. The measurement results of the pH value of avocados on day 0 was around 6.8 while the day 7 showed a pH value of 7.3. The increase in pH is thought to have occurred due to the climacteric properties of avocado, in which the ripening process continues during storage, resulting in a drop in fruit acidity and an increase in pH. This is in accordance with (Muchtadi 2010) which state that young fruit contains a lot of organic acids that will decrease during the fruit ripening process and is supported by a statement (Bambang Kuswandi et al. 2012) that pH changes can significantly be known because of the formation of acetic acid during the ripening process.

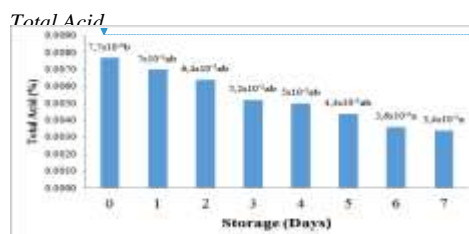


Fig 3. Total Acid Measurement Results on Avocado Fruit during Storage. Mean values (N=3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of total

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acid content of avocado fruit during storage.

The results of variance analysis showed that total acid on day 0 was significantly different from total acid on day 6 and 7 and was not significantly different from day 1, 2, 3, 4 and 5. The total acid value on day 0 is around  $7.7 \times 10^{-3}\%$  and has decreased to  $3.4 \times 10^{-3}\%$  on day 7. The reduction in the total acidity of avocado packaged during storage is caused by the use of organic acids in avocados during the respiration process which requires energy during storage, the energy needed is obtained by overhauling nutrients contained in food. Also supported by (Tranggono and Sutardi 1989) stated that the total content of acid would decrease during the maturation period and together with the decrease in total acid, a reduction in starch content occurs.

Total Dissolved Solids (TDS)

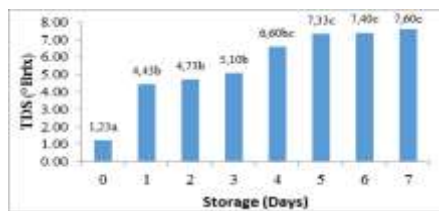


Fig 4. Total Dissolved Solids of Avocado Fruit during Storage. Mean values (N=3) within the bars with different letters indicate significant difference (p<0.05) of TDS of avocado fruit during storage.

Based on analysis of variance, avocados stored for seven days showed that the TDS on day 0 was significantly different from the TDS on other days from day 1 to day 7. While the TDS on the first day was significantly different from day 0, 5, 6 and 7 and not significantly different from day 2, 3 and 4. The test results for total dissolved solids on day 0 showed a value that was equal to 1.23°Brix and experienced an increase on day 7 which was 7.60°Brix. Based on these results it was known that during the storage, total dissolved solids on avocados increased. The step up in total dissolved solids is caused by the breakdown of carbohydrate polymers, especially starch in avocados, into sugar resulted in an increase in sugar content in general. This result is consistent with (Buckle and Edward 2013) statement that the higher the concentration of sucrose contained in a ripe fruit will produce a high total dissolved solid.

Vitamin C

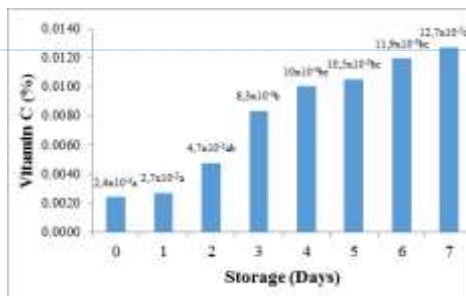
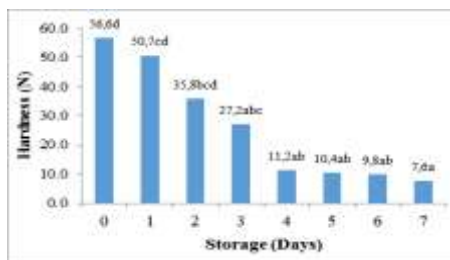


Fig 5. Vitamin C Measurement Results of on Avocado Fruit During Storage. Mean values (N=3) within the bars with different letters indicate significant difference (p<0.05) of vitamin C content of avocado fruit during storage

The results of variance analysis showed that the vitamin C content on day 0 was significantly different from the day 3, 4, 5, 6 and 7 and was not significantly different from the day 1 and 2. The results of vitamin C measurement on the day 0 showed a value that was equal to  $2.4 \times 10^{-3}\%$  and continuously increased until day 7 which reached  $12.7 \times 10^{-3}\%$ . The increase of vitamin C content is because generally in fruits contain vitamin C, the vitamin C increase is in accordance with the development of fruit. When the fruit is still in a young state the content of vitamin C is very low while when the size of fruit reaches the maximum level, same goes to the vitamin C. This is in accordance with (Pantastico 1975) which state that the content of vitamin C in fruit is usually in accordance with the development of fruit. Young fruit contain low level of vitamin C while when the fruit size reaches the maximum level, the vitamin C is also maximum.

Hardness



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 Fig 2. Total Acid Measurement Results on Avocado Fruit during Storage.¶

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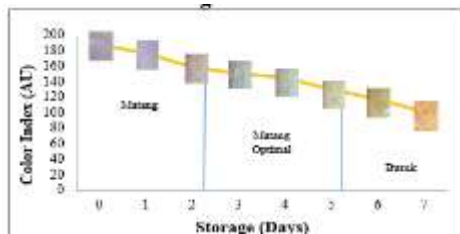
Deleted: Fig 4. Vitamin C Measurement Results of on Avocado Fruit During Storage.¶

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**Fig 6. Measurement Results of Hardness Level on Avocado Fruit during Storage.** Mean values (N=3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of hardness of avocado fruit during storage

The results of analysis of variance showed that the hardness level of avocados on day 0 was significantly different from day 3, 4, 5, 6 and day 7 and not significantly different from the day 1 and 2. The value of the hardness level of avocados showed that on the first day was 56.6 N and decreased gradually up to 7.6 N on day 7. Decrease in the hardness of avocados during storage due to the hydrolysis of cell wall composition during the ripening process. This result was supported by (Nelson, Plotz, and Kepler 2006) that during the ripening process of fruit, the hydrolysis of pectin and hemicellulose which is a component that forms cell walls occurs and causes fruit softening

**Color Change Index**



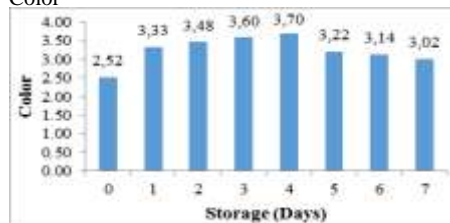
**Fig 7.** Color Change Profile on the Indicator of Avocado Freshness.

The results of these observations indicated that there was a color level change of the indicator (the intensity of purple that changes) to various levels of freshness during storage. In Fig 6, the color change response decreased continuously (the change became red), in which on day 0, the intensity of the light purple color is 189 AU. While on day 7, it decreased to 121 AU. Color changes that occur are due to the release of volatile acids such as acetic acid in avocados during storage which is directly bound to the indicator. The purple color indicated mature fruit (in this condition the fruit has physical characteristics if observed in a visual way, in which the surface of the fruit skin looked like there is a layer of wax, fresh dark green, had a solid and filled shape, had a hard texture and a bit bitter taste). Indicator color changes to yellowish blue indicated that the fruit ripens optimally (this condition the fruit experiences a decrease in hardness or softening fruit, green fruit flesh color, green fruit skin color is less fresh, and sweet taste). Changing the color of the indicator from yellowish blue to red indicates that the packaged fruit has been decayed (in this condition the texture of the fruit is getting softer, the taste of the fruit is sweet and somewhat bitter, the

skin color of the fruit is not fresh and runny). The result obtained was inconsistent with (Bambang Kuswandi et al. 2012) that all color indicators placed in the packaging are used to detect changes in pH as a result of the biosynthesis of volatile acids which come out gradually in the packaging during the ripening process

**Organoleptic**

**Color**

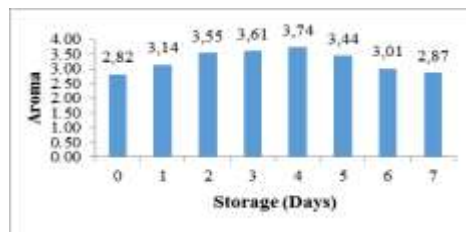


**Fig 8.** Organoleptic Test for Color in Avocado Fruit during Storage

The panelists' assessment of the color of avocados showed that the color of the fruit preferred by the panelists was fruit at the day 4 of storage with an average value of 3.70. The color Avocado had on day 4 were green color and flesh with yellowish green color. This change is due to the drastic degradation of the chlorophyll pigment during the cooking stage which coincides with the rate of reduction of reducing sugars. The result was in accordance with (Winarno 2008), who stated that color changing in food can be caused by several sources and one of the most important sources is pigments contained in vegetable and animal ingredients.

**Aroma**

The panelists' assessment of the aroma of avocados showed that the fruit aroma preferred by panelists was on day 4 of storage with an average value of 3.74. The aroma produced on day 4 is a distinctive aroma of avocado. This aroma occurred because the fruit has undergone optimal maturation and the release of ethylene or esters during ripening takes place. This result was supported by the opinion of (Pantastico 1975), who states that a typical odor arises around a ripe fruit which is usually produced when entering the climatic form of aliphatic alcohol esters and short chain fatty acids.



**Fig 9.** Organoleptic Test of Aroma on Avocado Fruit during Storage

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### Texture

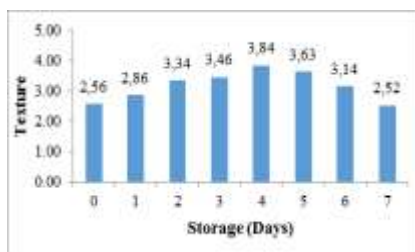


Fig 10. Organoleptic Texture Test on Avocado Fruit during Storage

The panelists' assessment of the texture of avocados showed that the fruit texture preferred by panelists was at day 4 of storage with an average value of 3.84. The texture avocado had on day 4 was the overall texture of the base of the fruit which was still rather hard, but the flesh of the fruit has a soft and not too hard texture. The texture indicated that on the day 4 of storage, avocado experienced the optimal ripening. The occurrence of softening of avocados during storage is caused by hydrolysis of the fruit cell wall component during the ripening process so that the cell component became soft. Texture softening involved enzymes. The enzyme is an enzyme called polygalacturonase that generally found in avocados. This explanation was supported by (Barbut 2014), stating that the fruit ripening process occurs hydrolysis of the components forming the cell wall which causes the fruit to become soft during the ripening process.

### Taste

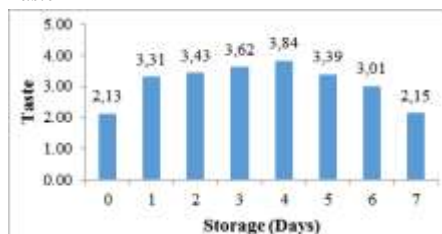


Fig 11. Organoleptic Test on Taste of Avocado Fruit during Storage

The panelists' assessment of avocado flavor showed that the fruit flavor favored by panelists was at day 4 of storage with an average value of 3.84. The taste produced on day 4 is sweet and slightly bitter. This taste indicated that avocados had undergone optimal maturation. This change in taste occurs because of the hydrolysis of starch into simpler sugars, as a result of the breakdown of starch which causes an increase in fruit reducing sugar levels which can cause sweetness and is accompanied by a decrease in levels of organic acids and phenolic substances which is usually related to a sour taste. [This explanation was in accordance with the statement of Winarno \(2008\)](#), that when the fruit is ripe the sugar content increases and the organic acid content decreases, as a result the sugar and acid ratio will change so that the fruit tastes better. This also supported by [Tranggono and Sutardi \(1989\)](#), who states that the total acid content will decrease during the ripening period and together with the decrease in total acid, the starch content decreases, while the sugar content as a determinant of fruit sweetness increases.

### Conclusion

The conclusions of this research were:

1. The freshness indicator of avocados can be made by using red cabbage as a natural solution and using Whatman filter paper number 1 as an absorbent material for red cabbage extract with the paper size of  $\pm 2 \times 4$  cm.
2. Application of smart packaging on avocados could be done by placing indicators in the packaging with a distance of  $\pm 2$  cm from the avocado.

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**Deleted:** In addition, the bitter taste was formed from tannin that generally found in avocados. This explanation was in accordance with the statement in accordance with (Winarno 2008)

**Deleted:** flower increases, but the organic acid content decreases as a result the sugar and acid ratio will change so that the fruit tastes better. Also supported by (Tranggono and Sutardi 1989)

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4.	Jalil Genisa	PhD (Professor)		Supervision

18 September 2021



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(Signature of corresponding author)

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Original Research Paper

# The Utilization of Red Cabbage Extract (*Brassica oleracea*) in the Production of Avocado (*Persea americana* Mill) Freshness Indicator as Smart Packaging Element

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**Abstract:** This research aimed to study and produce smart packaging indicator by utilizing red cabbage extract which could be applied to avocados. The research was conducted in a laboratory with the following stages; making red cabbage extract, preparing color indicator and applying it to smart packaging. The results showed that the soaking time and pH of the red cabbage extract solution as an indicator solution which was suitable for making freshness indicator of avocado were 15 h with the temperature of  $28\pm 2^{\circ}\text{C}$  and pH 7. The color indicator that had been applied to the packaging had a color change from light purple to red that visible with the naked eye. The color change of the indicator reflected the freshness level of packaged avocado, in which the purple color showed mature, yellowish blue showed the optimal ripe fruit while the red color indicated the fruit rotten during storage. Indicator changes also had a similar tendency towards changes in several parameters such as increasing pH, total acid, vitamin C, hardness and total dissolved solids which are usually used to characterize the freshness of avocados. Organoleptic tests namely color, aroma, texture and taste showed that the panelists preferred the avocado on day 4. In general, this indicator could be used as smart packaging.

**Keywords:** Shelf Life, Fruit, Food Quality

## Introduction

Avocado is a type of climacteric fruit. Climacteric fruit is a fruit that has increased respiration and ethylene during the fruit ripening (Cherian *et al.*, 2014). Based on the data of the Directorate General of Indonesia Horticulture in 2015, avocado is classified as one of the fresh fruit commodities with a high level of production targets. The target of avocado production in 2015-2019 is around 300,780 - 325,561 tons. However, avocados are very susceptible to damage either due to microbiological disturbances, environmental temperature or mechanical damage. Mechanical damage is caused by transportation with a very long distance. This is due to the tendency of the fruit that does not have a uniform shape and size causes susceptibility to experience friction. Consequently, avocados have a relatively short shelf life.

One way to minimize damage to avocados is by using smart packaging (Hong and Park, 1999; Yam *et al.*, 2005; Kuswandi *et al.*, 2011; Andi Dirpan *et al.*, 2018). Smart packaging is a package equipped with indicators to monitor the quality and safety of food products during storage, transportation and marketing (Kuswandi *et al.*,

2012; Siracusa *et al.*, 2008; Hidayat *et al.*, 2019; Dirpan *et al.*, 2019; Julyaningsih *et al.*, 2020; Yolanda *et al.*, 2020). Several studies about smart packaging in the form of indicator labels have been carried out. Dirpan *et al.* (2018) has been researching smart packaging color indicator to detect the quality of mango (Andi Dirpan *et al.* 2018) Besides that, previous studies have implemented smart packaging in beef, milk (Cavallo *et al.*, 2014), shrimp (Kuswandi *et al.*, 2012), kimchi (fermented vegetable product) (Hong and Park, 2000; 1999) and guava (Kuswandi *et al.*, 2013).

One source of natural dyes can be obtained from the commodity of red cabbage. Red cabbage is a plant that contains a lot of anthocyanins. Anthocyanin is a pigment that can dissolve in water. Chemically anthocyanins can be grouped into flavonoids and phenolics. These substances play a role in the coloration of red cabbage (Harborne *et al.*, 2006). So that in this research red cabbage was utilized as a natural indicator that was immobilized into paper Whatman no. 1.

The application of smart packaging with the use of red cabbage extract as an indicator of avocados' freshness has not been applied. Therefore, this study aimed to understand:

How to make smart packaging elements as an indicator of fruit freshness in avocado (*Persea americana* mill) with the utilization of red cabbage extract (*Brassica oleracea*)? how to apply smart packaging to avocados? and What is the color change profile on the freshness indicator of the avocado (*Persea americana* mill)?.

## Research Methods

### Time and Place

This research was conducted on April-June 2018 in the Laboratory of Food Microbiology and Biotechnology, Laboratory of Chemistry Analysis and Food Quality Control and Laboratory of Food Processing, Program Study Food Science and Technology, Department of Agricultural Technology, Hasan Uddin University, Makassar.

### Equipment and Materials

Equipment used in this experiment were hair dryer (Philips), Erlenmeyer 300 mL, drop pipette, hot plate, penetrometer, pH meter, knife, basin, mortar and pestle, stirrer, analytical balance, funnel, blender, centrifuge, volumetric flask, bulb, volume pipette, hand refractometer, beaker glass, digital microscope (model: Digital microscope 5-500 x) and titration set manual.

Materials used in this experiment were: Avocados and red cabbage (purchased in fresh condition from the supermarket), NaOH solution (Merck), HCl solution (Rofa), styrofoam, Whatman paper No. 1 (Whatman), ethanol, demineralized water, amylum solution, phenolphthalein solution (Merck), iodine solution (Merck), polyethylene plastic, aluminum foil, tissue and label.

## Research Procedure

The research conducted consisted of two stages, namely, preliminary and main research.

### Preliminary Research

#### Red Cabbage Extract Making

We cut red cabbage into small pieces and then weighed an amount of 600 grams. After that, the cabbage was mashed with a blender and macerated with 160 mL ethanol-distilled water (ratio 7:3). We adjusted the pH of the sample to 2.0 with HCl (1 mol/L). Then, the material was stored at 10°C in the refrigerator for 24 h. We then centrifuged the cabbage solution at 5000 rpm for 20 min. The centrifugation resulted cabbage extract. We filtered the cabbage extract using Whatman paper No. 1 to obtain clear cabbage extract. We then adjusted the pH of extract to alkaline condition (pH 7, 9 and 11) Modified from Silva-Pereira *et al.* (2015).

### Preparation of the Color Indicator Label

We cut the Whatman no 1 paper sheets in size 2×4 cm then we soaked it in 10 mL of red cabbage indicator solution at room temperature (28±2°C) for 5, 15 and 30 h. The treatment was carried out to obtain the best treatment in producing color changes. If the indicator solution succeeded in reacting with Whatman paper, it would give light purple on Whatman No. 1 which was white. Next, Whatman paper 1 dried with an electric dryer.

### Main Research

#### Smart Packaging Application on Avocado Fruit

We weighed around 500 grams of Avocado by two pieces (each packaging container), then placed it on a styrofoam tray. Then the indicator paper was affixed to the packaging label and placed in the packaging, by attaching the packaging indicator label to the polyethylene plastic as a styrofoam cover (Fig. 1). Samples were stored in room conditions (28±2°C) with normal light exposure. Triple packages of avocado products taken at the right time interval (every 1 day for 7 days) for analysis of pH, total vitamin C, Total Dissolved Solids (TDS), total acid, fruit hardness and color index on packaging indicator paper of avocado.

### Research Design

The research design that was carried out for preliminary research was the determination of the pH of the indicator solution and the determining of the best soaking time. The type of pH of the indicator solution and soaking time were:

- A1: Red cabbage extract solution pH 7
- A2: Red cabbage extract solution pH 9
- A3: Red cabbage extract solution pH 11
- B1: Soaking for 5 h
- B2: Soaking for 15 h
- B3: Soaking for 30 h

The best treatment from each of the mentioned steps was then used in the primary research for making smart packaging indicators for avocados. Then, the indicator label was applied to the packaging of avocados with a storage time of 7 days in a room temperature (28±2°C).

### Observation Parameters

The observation parameters were carried out by several tests, namely pH measurement method (AOAC, 1995), total acid titration method (Retnowati and Kusnadi 2013) total dissolved solids (hand refractometer) (Hurriyah and Pratoko, 2017), Vitamin C (Helmiyesi *et al.*, 2008), organoleptic in the form of texture, taste, color and aroma (Setyaningsih *et al.*, 2010) and quantification of indicator color measurement (Francis 1994; Gunasekaran 1996; Yam and Papadakis, 2004).



**Fig. 1:** Smart packaging application on Avocado fruit

### Statistical Analysis

One-way Analysis of Variance (ANOVA) applied to analyze the pH, total acid, Total Dissolved Solid (TDS), vitamin C and hardness, while the significant differences among means were determined using Tukey's test with a level of significance of  $p < 0.05$ . SPSS software for Windows version 16.0 (SPSS Inc., IL, USA) and Microsoft Excel 2010 was used to analyze the data

## Results and Discussion

Based on the results of preliminary research conducted, it was known that the soaking time and pH of the red cabbage extract solution as an indicator solution suitable for making indicators of avocado freshness were 15 h with the temperature of  $28 \pm 2^\circ\text{C}$  and pH 7. It can be seen through the significant color change of the indicator label that was applied to the avocado. The use of red cabbage extract as a natural solution immobilized to What man paper number 1 which produced an indicator label that was applied to avocados could change in color due to the release of volatile acids such as acetic acid in avocados during storage which is directly bound to the indicator. The color purple indicated that the fruit is highly fresh, then experiencing a change in color to yellowish blue showed fresh fruit and turning to red indicated that the fruit is experiencing the beginning of decay.

### pH

Based on the pH measurement of packaged avocados using pH meters' in Fig. 2, it showed that there was an increase in pH every day during storage. The results of the analysis of variance showed that the pH value on day 0 was significantly different from day 4, 5, 6 and day 7 and not significantly different from day 1, 2 and day 3. The measurement results of the pH value of avocados on day

0 was around 6.8 while the day 7 showed a pH value of 7.3. The increase in pH is thought to have occurred due to the climacteric properties of avocado, in which the ripening process continues during storage, resulting in a drop in fruit acidity and an increase in pH. This is in accordance with (Muchtadi *et al.*, 2010) which state that young fruit contains a lot of organic acids that will decrease during the fruit ripening process and is supported by a statement (Kuswandi *et al.*, 2012) that pH changes can significantly be known because of the formation of acetic acid during the ripening process.

### Total Acid

Here we commence our discussion of the total acid in Fig. 3. The results of variance analysis showed that total acid on day 0 was significantly different from total acid on day 6 and 7 and was not significantly different from day 1, 2, 3, 4 and 5. The total acid value on day 0 is around  $7.7 \times 10^{-3}\%$  and has decreased to  $3.4 \times 10^{-3}\%$  on day 7. The reduction in the total acidity of avocado packaged during storage is caused by the use of organic acids in avocados during the respiration process which requires energy during storage, the energy needed is obtained by overhauling nutrients contained in food. Also supported by (Tranggono and Sutardi, 1989) stated that the total content of acid would decrease during the maturation period and together with the decrease in total acid, a reduction in starch content occurs.

### Total Dissolved Solids (TDS)

Figure 4 provides a quantitative analysis of the TDS. Based on analysis of variance, avocados stored for seven days showed that the TDS on day 0 was significantly different from the TDS on other days from day 1 to day 7. While the TDS on the first day was significantly different from day 0, 5, 6 and 7 and not significantly different from day 2, 3 and 4. The test results for total dissolved solids on day 0 showed a value that was equal to 1.23°Brix and experienced an increase on day 7 which was 7.60 °Brix. Based on these results it was known that during the storage, total dissolved solids on avocados increased. The step up in total dissolved solids is caused by the breakdown of carbohydrate polymers, especially starch in avocados, into sugar resulted in an increase in sugar content in general. This result is consistent with (Buckle and Edward, 2013) statement that the higher the concentration of sucrose contained in a ripe fruit will produce a high total dissolved solid.

### Vitamin C

The results of vitamin c are summarised in Fig. 5. The results of variance analysis showed that the vitamin C content on day 0 was significantly different from the day 3, 4, 5, 6 and 7 and was not significantly different from the day 1 and 2.

The results of vitamin C measurement on the day 0 showed a value that was equal to  $2.4 \times 10^{-3}\%$  and continuously increased until day 7 which reached  $12.7 \times 10^{-3}\%$ . The increase of vitamin C content is because generally in fruits contain vitamin C, the vitamin C increase is in accordance with the development of fruit. When the fruit is still in a young state the content of vitamin C is very low while when the size of fruit reaches the maximum level, same goes to the vitamin C. This is in accordance with (Pantastico, 1975) which state that the content of vitamin C in fruit is usually in accordance with the development of fruit. Young fruit contain low level of vitamin C while when the fruit size reaches the maximum level, the vitamin C is also maximum.

### Hardness

Let's turn to the results of hardness in Fig. 6. The results of analysis of variance showed that the hardness level of avocados on day 0 was significantly different from day 3, 4, 5, 6 and day 7 and not significantly different from the day 1 and 2. The value of the hardness level of avocados showed that on the first day was 56.6 N and decreased gradually up to 7.6 N on day 7. Decrease in the hardness of avocados during storage due to the hydrolysis of cell wall composition during the ripening process. This result was supported by (Nelson *et al.*, 2006) that during the ripening process of fruit, the hydrolysis of pectin and hemicellulose which is a component that forms cell walls occurs and causes fruit softening.

### Color Change Index

The results of these observations indicated that there was a color level change of the indicator (the intensity of purple that changes) to various levels of freshness during storage. In Fig. 7, the color change response decreased continuously (the change became red), in which on day 0, the intensity of the light purple color is 189 AU. While on day 7, it decreased to 121 AU. Color changes that occur are due to the release of volatile acids such as acetic acid in avocados during storage which is directly bound to the indicator. The purple color indicated mature fruit (in this condition the fruit has physical characteristics if observed in a visual way, in which the surface of the fruit skin looked like there is a layer of wax, fresh dark green, had a solid and filled shape, had a hard texture and a bit bitter taste). Indicator color changes to yellowish blue indicated that the fruit ripens optimally (this condition the fruit experiences a decrease in hardness or softening fruit, green fruit flesh color, green fruit skin color is less fresh and sweet taste). Changing the color of the indicator from yellowish blue to red indicates that the packaged fruit has been decayed (in this condition the texture of the fruit is getting softer, the taste of the fruit is sweet and somewhat bitter, the skin color of the fruit is not fresh and runny). The result obtained was inconsistent with

(Kuswandi *et al.*, 2012) that all color indicators placed in the packaging are used to detect changes in pH as a result of the biosynthesis of volatile acids which come out gradually in the packaging during the ripening process.

### Organoleptic Color

The panelists' assessment of the color of avocados in Fig. 8 showed that the color of the fruit preferred by the panelists was fruit at the day 4 of storage with an average value of 3.70. The color Avocado had on day 4 were green color and flesh with yellowish green color. This change is due to the drastic degradation of the chlorophyll pigment during the cooking stage which coincides with the rate of reduction of reducing sugars. The result was in accordance with (Winarno, 2008) who stated that color changing in food can be caused by several sources and one of the most important sources is pigments contained in vegetable and animal ingredients.

### Aroma

The panelists' assessment of the aroma of avocados in Fig. 9 showed that the fruit aroma preferred by panelists was on day 4 of storage with an average value of 3.74. The aroma produced on day 4 is a distinctive aroma of avocado. This aroma occurred because the fruit has undergone optimal maturation and the release of ethylene or esters during ripening takes place. This result was supported by the opinion of (Pantastico, 1975), who states that a typical odor arises around a ripe fruit which is usually produced when entering the climatic form of aliphatic alcohol esters and short chain fatty acids.

### Texture

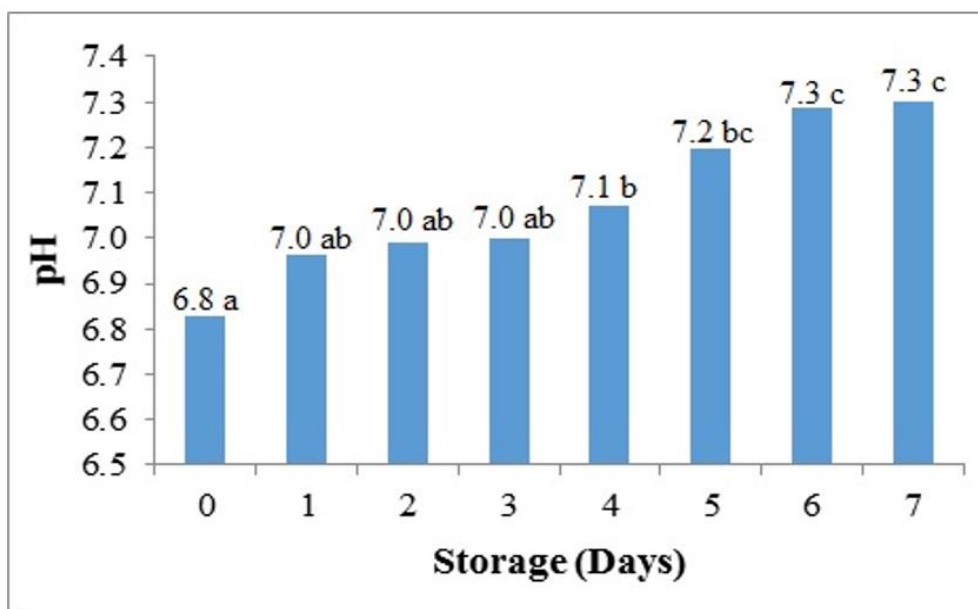
The panelists' assessment of the texture of avocados in Fig. 10 showed that the fruit texture preferred by panelists was at day 4 of storage with an average value of 3.84. The texture avocado had on day 4 was the overall texture of the base of the fruit which was still rather hard, but the flesh of the fruit has a soft and not too hard texture. The texture indicated that on the day 4 of storage, avocado experienced the optimal ripening. The occurrence of softening of avocados during storage is caused by hydrolysis of the fruit cell wall component during the ripening process so that the cell component became soft. Texture softening involved enzymes. The enzyme is an enzyme called polygalacturonase that generally found in avocados. This explanation was supported by (Barbut, 2014), stating that the fruit ripening process occurs hydrolysis of the components forming the cell wall which causes the fruit to become soft during the ripening process.

### Taste

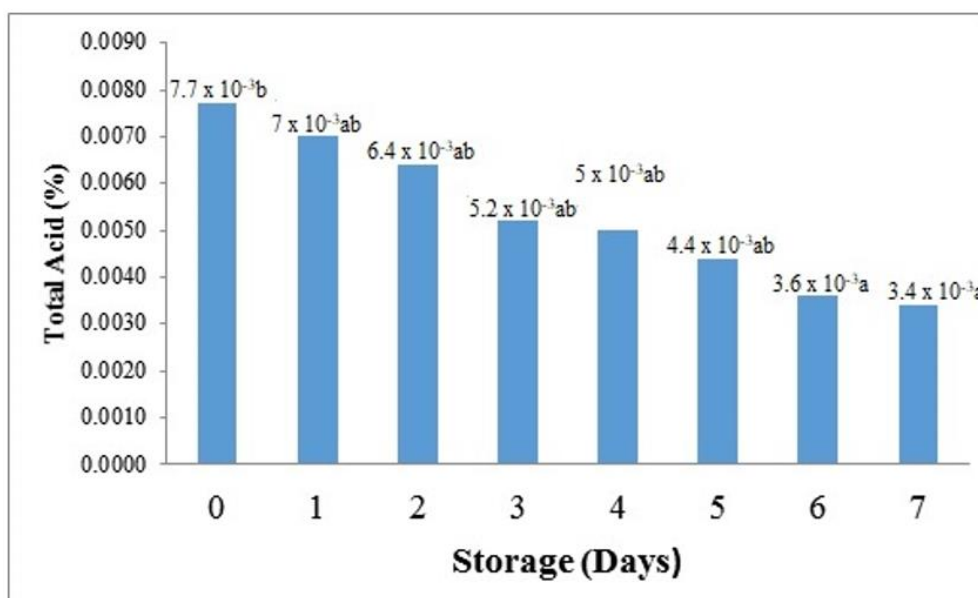
The panelists' assessment of avocado flavor in Fig. 11 showed that the fruit flavor favored by panelists was at day 4 of storage with an average value of 3.84. The taste

produced on day 4 is sweet and slightly bitter. This taste indicated that avocados had undergone optimal maturation. This change in taste occurs because of the hydrolysis of starch into simpler sugars, as a result of the breakdown of starch which causes an increase in fruit reducing sugar levels which can cause sweetness and is accompanied by a decrease in levels of organic acids and phenolic substances which is usually related to a sour taste. This explanation was in accordance with the

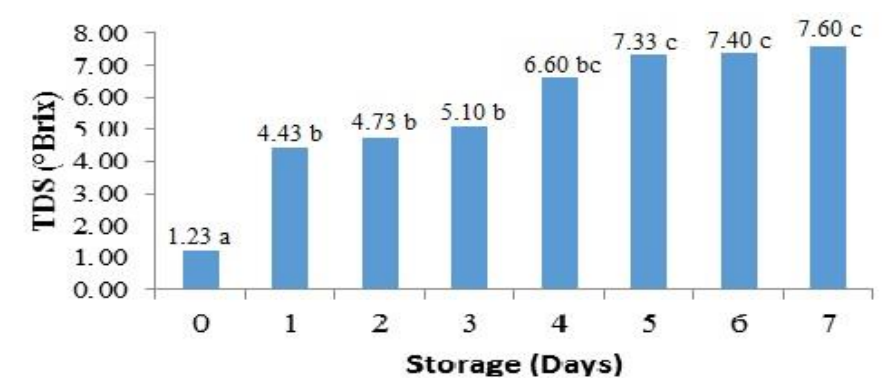
statement of Winarno (2008) that when the fruit is ripe the sugar content increases and the organic acid content decreases, as a result the sugar and acid ratio will change so that the fruit tastes better. This also supported by Tranggono and Sutardi (1989), who states that the total acid content will decrease during the ripening period and together with the decrease in total (1) acid, the starch content decreases, while the sugar content as a determinant of fruit sweetness increases.



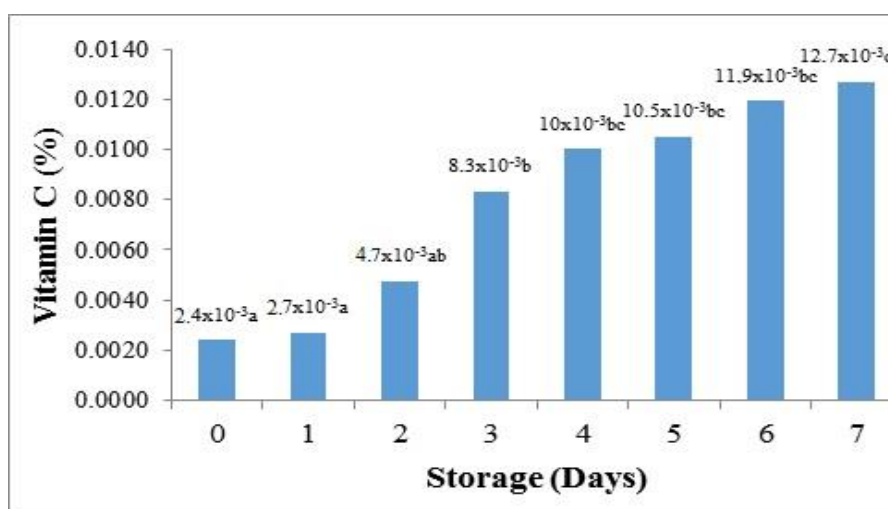
**Fig. 2:** The results of pH measurement on avocados during storage. Mean values (N = 3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of pH of avocado fruit during storage



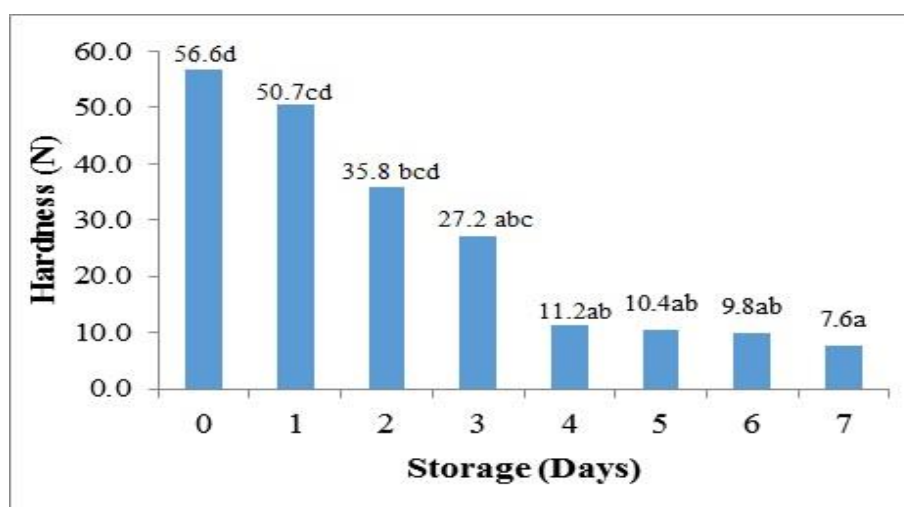
**Fig. 3:** Total acid measurement results on avocado fruit during storage. Mean values (N = 3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of total acid content of avocado fruit during storage



**Fig. 4:** Total dissolved solids of avocado fruit during storage. Mean values (N = 3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of TDS of avocado fruit during storage



**Fig. 5:** Vitamin C measurement results of on avocado fruit during storage. Mean values (N = 3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of vitamin C content of avocado fruit during storage



**Fig. 6:** Measurement results of hardness level on avocado fruit during storage. Mean values (N = 3) within the bars with different letters indicate significant difference ( $p < 0.05$ ) of hardness of avocado fruit during storage

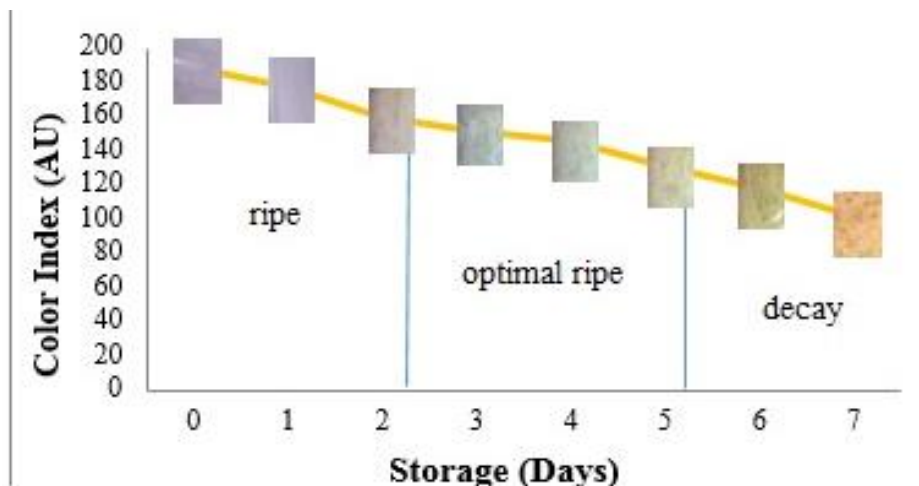


Fig. 7: Color change profile on the indicator of avocado freshness

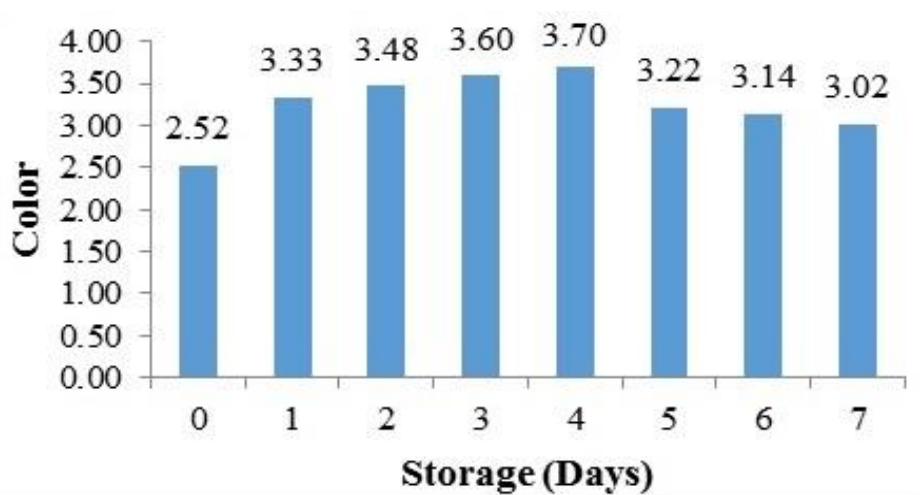


Fig. 8: Organoleptic test for color in avocado fruit during storage

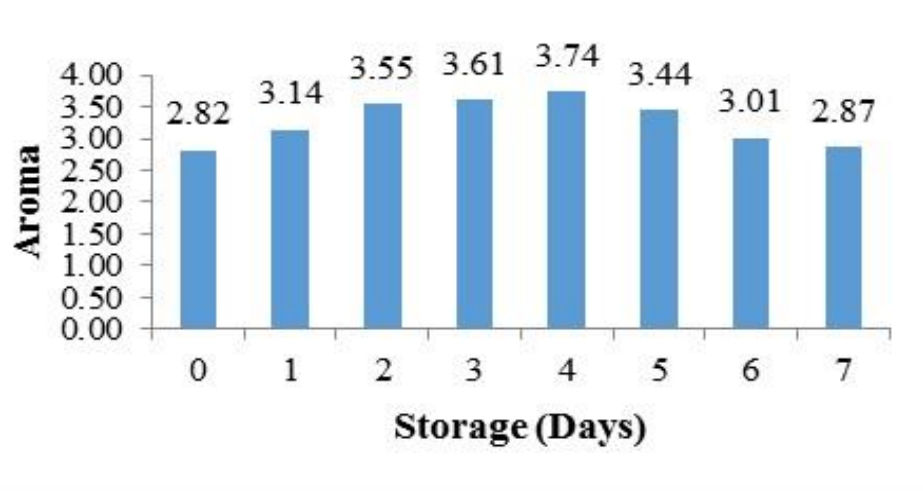


Fig. 9: Organoleptic test of aroma on avocado fruit during storage

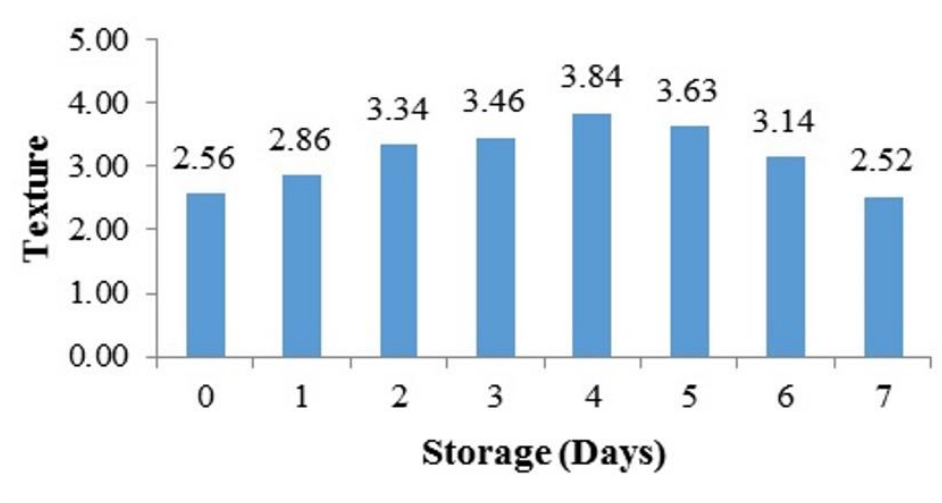


Fig. 10: Organoleptic texture test on avocado fruit during storage

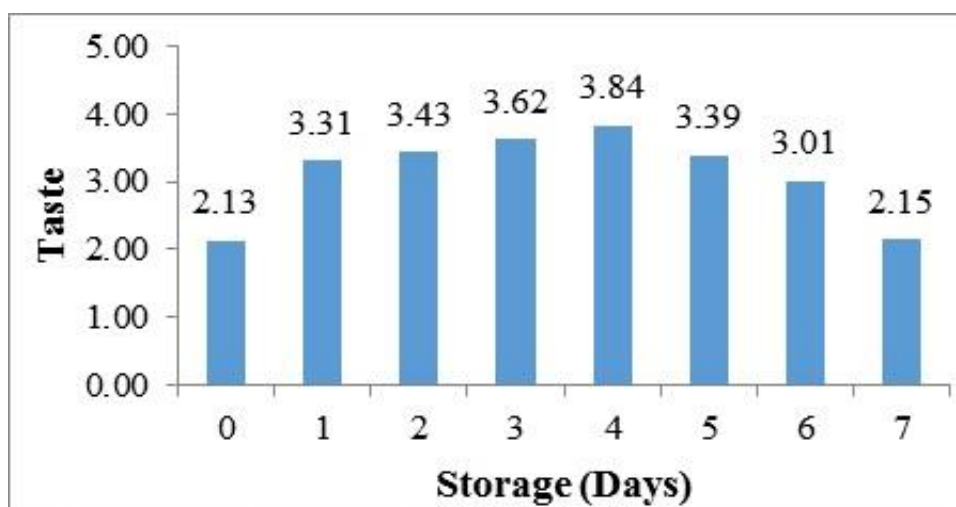


Fig. 11: Organoleptic test on taste of avocado fruit during storage

## Conclusion

The conclusions of this research were:

1. The freshness indicator of avocados can be made by using red cabbage as a natural solution and using Whatman filter paper number 1 as an absorbent material for red cabbage extract with the paper size of  $\pm 2 \times 4$  cm.
2. Application of smart packaging on avocados could be done by placing indicators in the packaging with a distance of  $\pm 2$  cm from the avocado.

## Authors and Contribution

**Andi Dirpan:** Conceptualization, Methodology, Validation.

**Muspriah Djalal:** Writing - Original Draft, Validation.

**Riskawanti Rahman:** Data Curation.

**Jalil Genisa:** Supervision.

## Ethics

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